III-14.01 Introduction

The safety review is used to determine what roadside obstructions are cost effective to eliminate, relocate beyond the roadway clear zone, or make crashworthy. Obstructions include, but are not limited to: non yielding/non-breakaway signs, light standards, and utility poles, signal standards, culvert (or end section) openings over 36 inches, box culverts, bridge rail ends, bridge piers, trees having a mature diameter of 4" or larger, large rocks, water over 2 feet deep, and foreslopes that are steeper than 3:1. The *Roadside Design Guide*, published by AASHTO, contains the guidelines used to determine what constitutes an obstruction and how the obstruction should be dealt with.

The guidelines presented in this section are to be followed when a full safety review is required. Major Rehabilitation projects require a full safety review.

III-14.02 Obstruction Clearance

The obstruction clearance is the "zone" adjacent to the traveled way in which existing roadside features are reviewed. The obstruction clearance is not the same thing as the clear zone. It is strictly used for the initial review of existing roadside features only.

An obstruction clearance of 20' from the edge of the driving lane is used to review all 2-lane rural highways. On freeways, expressways, & urban roadways (40 mph or less), the distance used for the obstruction clearance should be taken from tables 1 and 2 in Appendix III-14B.

III-14.03 Clear Zone

Clear zone is defined as the total roadside area, beyond the edge of the through traveled way, which is traversable and free of obstructions. The desired clear zone width is dependent upon the traffic volume, travel speed, and upon the roadway and roadside geometry. (See Tables 1 and 2 in Appendix III-14 B for clear zone distances and horizontal curve adjustments.) See Design Manual Section III-15 "Clear Zones" for more information on clear zones.

III-14.04 Field Survey

The field surveys are made to determine the location and size of all obstructions along the roadway. Refer to Chapter 18 of the Survey Manual for an explanation of the data collection process.

III-14.05 Safety Enhancements

All obstructions within the obstruction clearance should have one of six safety enhancements performed. In order of preference, these are:

1. Remove the obstruction.
2. Make the obstruction traversable.
3. Relocate the obstruction beyond the clear zone.
4. Reduce impact severity by using an appropriate breakaway system.
5. Shield the obstruction with a longitudinal barrier or crash cushion (only if obstruction cannot be removed, relocated, or redesigned.)
6. Delineate the obstruction (only if all above options are not appropriate.)

Attenuation devices, guardrail, and breakaway systems to be installed should be of a type that has been crash tested successfully in accordance with ARecommended Procedure for the Safety Performance Evaluation of Highway Features@ (NCHRP) Report 350.

The basic concept of the breakaway support is to provide a structure that will resist wind and ice loads, yet fail in a safe and predictable manner when struck by a vehicle. The term Abreakaway support@ refers to all types of sign, luminaire, and traffic signal supports that are designed to yield when struck by a vehicle. The release mechanism may be a slip base, base-bending, fracture elements, or a combination of these.

Any modifications or safety enhancements performed should be done in accordance with the design standards used for new construction. For instance, when an obstruction is relocated, it should be relocated beyond the clear zone rather than beyond the obstruction clearance.

III-14.06 Obstructions

An obstruction is anything that would hinder the recovery/movement of a vehicle that has left the traveled way. It could be a rigid object with a height greater than 4", an opening greater than 36", multiple openings greater than 30", or a foreslope steeper than 3:1. The following sections describe some of the more common obstructions found alongside the roadway.

III-14.06.01 Roadside Signs

Roadside signs can be divided into three main categories: overhead signs, large roadside signs, and small roadside signs. The hardware and corresponding safety treatment of sign supports varies with the sign category.

Overhead signs: Where possible, overhead signs should be installed on overpasses or other structures. Overhead signs generally require massive support systems which cannot be made breakaway. All overhead sign structures located within the obstruction clearance should be shielded with crashworthy barriers.

Large Roadside Signs: Large roadside signs may be defined as those greater than 50 ft^2 in area. They typically have two or more steel pipe or W-shape support posts which are breakaway. The following criteria should be satisfied if the support is to perform adequately as a breakaway support:

- The hinge should be a minimum of 7ft above the ground surface.
- A single post, or multiple posts with a post spacing greater than 7ft, should have a weight less than 45 lb/ft with a total weight of the support between the hinge and the breakaway base not to exceed 600 lb. For two or more posts with a post spacing less than 7ft, the post should not have a weight less than 18 lb/ft.
- No supplemental sign should be attached below the hinges. The sign may interfere with the performance of the breakaway support and/or it may enter the windshield if the sign is struck.
- The base plate of the anchoring unit shall not protrude above the ground more than 4” (see Figure 1 in Appendix III-14 A.)

Small Roadside Signs: Small roadside signs can be identified as signs having a sign surface area less than 50 ft^2 and they may be supported on one or more posts. A single support post is generally made of steel pipe or perforated tube and multiple supports are generally made of perforated tubes.

- Sign supports that are made from 2 1/4" 12 gauge steel or smaller square perforated tube (and do not have a reinforcing sleeve) are considered to be base-bending and do not require a breakaway base.

- U-channel posts, when used as single posts, are also considered base-bending and do not require a breakaway base. The U-channel post should not be spliced unless it has been crash tested.

- Sign supports that are made of wood, buried a minimum of 3ft in the ground, and 4"x 4" or smaller will yield when struck by a vehicle. Posts made of wood that are larger than 4"x 4" need to be weakened by having two holes drilled perpendicular to the roadway into the base of the sign support (see Figure 2 in Appendix III-14 A.)

- Supports made with steel pipe are not considered to be base-bending and are required to have a breakaway base.

- Diagonal bracing, also known as "A-frame", sign supports should not be used.

- The base plate of the anchoring unit shall not protrude above the ground more than 4" (see Figure 1 in Appendix III-14 A.)

III-14.06.02 Steep Foreslopes

Foreslopes parallel to the roadway can be categorized as recoverable, non-recoverable, traversable, or critical. A vehicle entering a critical foreslope is likely to overturn. A critical foreslopes is classified as a slope that has a rate steeper than 3:1.

When the foreslope is considered critical, the fill height and ADT of the roadway is examined. The depth of the fill is measured from the toe of the critical slope at the tie in with the ditch bottom to the top of the slope. If the fill height is 10' or less or if the forecast ADT is 750 or less, it is not considered cost effective to improve the slope. But, if the fill height is greater than 10' and the forecast ADT is greater than 750, foreslope flattening or guardrail protection should be considered. A cost effective analysis should be performed to determine which improvement should be done to the slope.

Many times drainage structures are located within steep slope areas. These structures may need to be extended when the slope is flattened. The cost for the extensions should be included in the cost to flatten the slopes. Use Section III-15B"Deep Fill Areas" to determine how the foreslope should be flattened.

It is the department's policy to flatten foreslopes even though the initial cost may be greater than the cost for installing guardrail. Therefore, when the safety review is written, both the costs for guardrail and the slope flattening should be included. This information should then be added to the Decision Section of the Project Concept Report as an executive decision.

III-14.06.03 Cross Slopes (Transverse Slopes)

Common obstacles on the roadside are embankment slopes created by median crossings, driveways, intersecting side roads, and ditch blocks. These slopes are more critical to errant vehicles than foreslopes and backslopes because they are struck by the vehicle directly. Cross slopes of 6:1 or flatter are acceptable, but median crossings and ditch block embankment cross slopes of 10:1 are desirable.

All ditch block cross slopes steeper than 6:1 should be flattened. On Interstate highways, they should be flattened to 10:1. On all other roadways, they should be flattened to 8:1.

The cross slopes of median crossings on the Interstate highways that are steeper than 6:1 should be flattened to 10:1 (see Figure 3 in Appendix III-14 A).

Cross slopes of side road approaches and median crossings (all roadways except the Interstate) that are steeper than 6:1 should be flattened to 8:1. The following criteria should be used when flattening the cross slopes:

- Flatten all 4:1 or steeper cross slopes where the forecast ADT is less than 500
- Flatten all cross slopes between 4:1 and 6:1 where the forecast ADT is less than 500 and it is cost effective
- Flatten all cross slopes steeper than 6:1 where the forecast ADT is greater than 500

Culverts located with the cross slopes may need to be extended when the slope is flattened.

III-14.06.04 Cross-Drainage Structures

Cross-drainage structures are used to move water under the roadway. They may consist of reinforced concrete pipes, corrugated metal pipes, structural plate pipes, or concrete box culverts. These structures can also be used by pedestrians, vehicles, or animals.

Cross-drainage structures with openings within the obstruction clearance should be made traversable, extended beyond the clear zone, or shielded with guardrail. Single structures with openings 36" or less and multiple structures with openings 30" or less are considered to be traversable and do not need to be improved.

Grates can be installed to make the openings of the cross-drainage structures traversable (see Figure 4 in Appendix III-14 A.) Smaller diameter (15" to 36") reinforced concrete pipes can be made traversable by removing the flared end section and installing a traversable end section. The detail for traversable end sections can be found on the NDDOT web site at http://www.dot.nd.gov/designmanual.html under plan preparation guide, plan sheets, section 700, 714.1 Culverts.

A cost effective analysis should be performed on all structures with openings within the obstruction clearance on roadways with a forecast ADT greater than 750. If it is determined that it is not cost effective to improve the structure, object markers should be installed.

It is not considered cost effective to improve structures with openings within the obstruction clearance on roadways with a forecast ADT of 750 or less. Therefore, these structures should have object markers installed.

III-14.06.05 Parallel Drainage Structures

Parallel drainage structures are those which parallel the mainline flow of traffic. These features can present a significant safety obstruction because they can be struck head-on by errant vehicles. Safety treatment options are similar to those for cross drainage structures:

- Eliminate the structure
- Use a traversable design
- Move the structure laterally to a less vulnerable location
- Shield the structure

Eliminating the structure may be difficult, but on field entrances and very low volume driveways, an overflow section may be constructed.

Traversable designs are to provide grates constructed of pipes set on 24 inch centers to reduce wheel snagging. Generally, pipes of 24 inch diameter or less may not require a grate. However, when a multiple pipe installation is encountered, grating smaller pipes may be appropriate.

Relocating the structure is the most desirable. This allows the opportunity to flatten the cross slope within the clear zone distance of the roadway. If the new culvert is located beyond the clear zone of the roadway, and will also be beyond the clear zone for the approach roadway, then relocation of the drainage structure should be considered. When a structure is relocated, it should be moved to at least 60 feet from the centerline of the roadway.
In cases where the cross slope cannot be made traversable, and the structure cannot be relocated or is too large to be safety treated effectively, it may be necessary to shield the obstacle with a traffic barrier.

III-14.06.06 Water

Streams or bodies of water with a depth of more than 2 feet within the obstruction clearance should be moved beyond the clear zone or shielded. A cost effective analysis should be performed to determine what action should be taken. The water should be present for long periods of time (one year or longer.)

III-14.06.07 Riprap

Riprap that is within the obstruction clearance and extends above the surrounding ground surface more than 4” should be removed to the clear zone or shielded. A cost effective analysis should be performed to determine what action should be taken.

If erosion control is necessary, an erosion control blanket should be installed after the riprap is removed. The cost for the erosion control blanket should be included in the cost for removing the riprap when the cost analysis is performed.

III-14.06.08 Light Standards, Signal Standards, Utility Poles, Trees, and Similar Roadside Features

Roadside features that are within the obstruction clearance and protrude above the surrounding surface more than 4” should be removed, made breakaway, relocated beyond the clear zone, or shielded.

Features, such as signal standards (with mast arms), utility poles, and railroad signals, cannot be made breakaway and should be relocated beyond the clear zone or shielded. Sometimes, features such as these need to be close to the roadway and cannot be relocated. In these instances, consideration should be given to installing a crash cushion to shield the supports.

Light standards and signal standards (without mast arms) should be made breakaway or relocated beyond the clear zone.

Trees with a mature size greater than 4" in diameter should be removed. If they cannot be removed they should be shielded.

III-14.06.09 Bridge Rail

The bridge railing should be of a type that is crashworthy. The bridge rails that the department uses and has accepted are: Jersey Barrier and Double Box Beam Rail Retrofit. Other types of bridge rail, such as the Sloped E-Rail, should be modified to a Double Box Beam Rail Retrofit.

III-14.06.10 Guardrail

Guardrail that has not been successfully crash tested in accordance with the guidelines of NCHRP Report 230 should be replaced with guardrail that has been successfully crash tested in accordance with the guidelines as set forth in NCHRP Report 350.

Guardrail should be checked to ensure that it meets the requirements for the design speed of the roadway. If one or more of the following deficiencies is present, the guardrail should be replaced with guardrail that meets current design practices:

- Guardrail that is attached to a safety shape transition (only if there is another deficiency or the approach slab is being replaced.)
- Guardrail tapers away from the roadway at a greater rate than what is required.
- There is insufficient space between guardrail and obstruction for proper deflection.
- The distance from the top of the guardrail to the ground surface is less than 26" or greater than 28' (after roadway improvement.)
- The guardrail is not long enough to shield the obstruction from an errant vehicle (see Length of Need in Section III-13 Guardrail.)

III-14.06.11 T-Intersection

Whenever a county, state, or US highway has an intersection or dead end with another state or US highway, there should be an approach or escape road provided for errant vehicles. If it is not feasible, other protective devices such as warning signs, rumble strips, or barricades should be provided (see Design Manual Section III-03.05.03 "Recovery Approaches").

III-14.07 Cost Effective Analysis

Collisions involving vehicles with roadside objects are a probable occurrence with any existing highway facility. The purpose of cost effective analysis is to provide a technique for comparing alternate solutions to problem locations. Present value of the total cost of each alternative is computed over a given period of time, taking into consideration initial cost, maintenance cost, and accident cost. The costs for each alternative are compared to the cost of the accidents that would occur if no safety enhancements were performed. The option with the least total cost would normally be chosen.

The Road Safety Analysis Program (RSAP) Software was developed under National Cooperative Highway Research Program (NCHRP) Project 22-9 and represents one approach to using the procedures described in Appendix A of the 2002 AASHTO *Roadside Design Guide*. The research for NCHRP Project 22-9 can be found in NCHRP Report 492, *Roadside Safety Analysis Program (RSAP)—Engineer's Manual*. The RSAP program is intended as a tool for economic analysis and should not supersede the guidelines presented in the *Roadside Design Guide* or sound engineering judgment.

The cost of making the improvements to enhance the safety of the roadside should be used to determine if the improvements are cost effective. The initial cost to make the improvements should be estimated to the nearest 100 dollars.

The maintenance costs to maintain the improvements should be on an annual basis. When guardrail is the improvement, the price for removal of snow should be included in the maintenance costs. Annual cost estimates for snow and ice maintenance should be obtained from the respective district office for specific locations.

The salvage value for the improvements at the end of the project life is typically considered zero, but may be used for W-beam guardrail. Note: If using the Road Safety Analysis Program (RSAP) software, it is not possible to input a salvage value.

The project life of a roadway design is an input value selected by the user. The discount rate is also a basic input value in the economic analysis.

Once the information is obtained, the total present worth and annualized costs are computed. The Road Safety Analysis Program (RSAP) software has been prepared to make a direct comparison between several proposed safety treatments.